Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

VOLUME LIII NUMBER 3

THE
BOTANICAL GAZETTE
MARCH 1912

THE MORPHOLOGY OF LEITNERIA FLORIDANA

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 154

WANDA M. PFEIFFER

(WITH PLATES XVIII–XX)

Former investigators examining *Leitneria* have come to such different conclusions as to its proper place among Archichlamydeae that it seemed worth while to look into its morphology in the hope that some interesting situations might be uncovered.

Material and methods

The material used was obtained from plants in the Missouri Botanical Garden of St. Louis. The first material was collected during the winter and spring of 1908, and was killed in a dilute solution of chromo-acetic acid by Miss LAURA D. WATKINS, who sent it to the laboratory in 70 per cent alcohol. I spent the last week in March 1908 in St. Louis. Pollen of *Leitneria* was beginning to be shed on March 28, which gave me an opportunity to pollinate some of the flowers of pistillate plants which stood a considerable distance from any staminate ones. During this week I made frequent collections in the hope of obtaining fertilization stages.

In the next year, living material was sent to me about twice a week from early in January until late in July. I again spent the week when pollen was ripe in St. Louis, and pollinated practically all the pistillate catkins in the garden except those which grew on seven twigs which were covered with paper sacks in order to prevent pollination. This last precaution was taken because the large amount of fruit produced in previous seasons on pistillate plants remote from staminate plants made the occurrence of parthenogenesis seem possible. The twigs bearing the catkins pollinated were carefully labeled, both as to the location in which they grew and the time of pollination. Again frequent collections (two every day) were made for about five days after pollination.

The first catkin collected had sections cut off each side to allow the more easy penetration of the killing fluid, and were then killed *in toto*. Owing to the difficulty in orienting the material, and to the fact that the hairs on the bracts made the cutting of smooth sections practically impossible, in all the later material the pistils and the stamens were picked out of the catkins before killing.

The young ovaries were killed in Flemming's weaker solution, while some of the later stages in the development of the ovule and of the seed were killed in 1 per cent chromo-acetic acid. The material was imbedded in paraffin and sections cut from 2–10 μ in thickness. The stains used were the combination of safranin and gentian violet, with the addition of gold orange in some cases. The solution of gold orange in clove oil to be used after clearing in clove oil was found to be more satisfactory than the alcoholic solution.

Historical

The work done on *Leitneria* previous to 1894 was largely taxonomic, and has been cited by TRELEASE (1) in a paper of that year describing the plants of *Leitneria* found growing in the lowlands of southeastern Missouri. He considered the habit and distribution of the plant and its various taxonomic features, and besides this the structure of the wood, calling attention to its extremely low specific gravity, and concluding with a discussion of the position *Leitneria* had held in various schemes of classification. The portion of the paper with which we are most concerned has to do with the catkins. Of these it is said:

> On mature plants the upper axillary buds are generally flower buds, and develop in the autumn into oblong, erect, subsessile, hairy catkins, about half an inch long, surrounded at base by bud scales, which pass into the very acute scales of the inflorescence. The trees are dioecious. . . . . The flowers expand

before the leaves, early in March. . . . . The staminate catkins then become from one to two inches long, generally curved outward, and their scales spread just enough to expose the stamens and allow the very abundant and powdery yellow pollen to escape. The soft parenchyma of the axis of inflorescence becomes torn in various directions as the catkins elongate, so that when they have reached their full development it is loosely fissured throughout. . . . . The staminate flowers, so far as I have examined them, are glabrous and quite destitute of a perianth or involucre of any description, and consist simply of a whorl of about ten short filaments, a little dilated at base and surmounted by slightly versatile but nearly erect, extrorse, two-celled anthers, dehiscing longitudinally. The pollen grains are nearly globose, smooth, slightly 3-4-grooved with underlying thickening of the intine, and fall from the dehiscent anther very readily, and there is no doubt that the species is wind-pollinated.

The pistillate catkin possesses the same loose lacunose structure as the staminate, though the axis is far less torn. When fully developed they are rarely over half an inch long. . . . . Unlike the staminate flowers, the pistillate, which are limited to the upper axils, are very short-stalked or with a rudimentary disk, and possess a rudimentary involucre or perianth of a few small, glandular-fringed scales, the largest two of which stand nearly laterally, while the remainder are dispersed along the side next the axis of the catkin. Only one carpel is present. The ovary is shortly ovoid, finely pubescent, one-celled, and contains a single ascending parietal ovule with the micropyle directed upward. The green or slightly reddish style is attached a little at one side, and in anthesis curves outwards and becomes grooved on the stigmatic side, or somewhat flattened, with the stigmatic surface undulated, possessing the general characters of wind-pollinated stigmas. The placenta and stigmatic groove are turned away from the axis and face the bract, a very unusual position for the suture in a monocarpellary flower, and one which appears to indicate that the flower is in reality reduced from a former state in which there were two carpels radially arranged with reference to the bract, or perhaps a larger number. . . . .

The fruit is an erect drupe. . . . . Its surface is coarsely rugose reticulated over the firm fibrovascular bundles of the pericarp. Near the top it is marked by an oblique scar left by the caducous style, and it contains a single large seed with a straight embryo and rather thin layer of albumen.

The microsporangium

The microsporangium passes the winter in the mother cell stage. In the youngest stamen examined there were four microsporangia, each with a considerable amount of sporogenous tissue in the mother cell stage. The mother cells numbered as high as five across the sporangium, while beyond these there sometimes were as many as six layers of cells, three of which might become tapetal, while the others formed the sporangium wall. On the opposite side of the sporangium the tapetum was usually only one layer of cells in thickness, these evidently derived from the sporogenous mass (fig. 1). In longitudinal section of the sporangium, the spore mother cells were seen to lie in plates somewhat separated from each other (fig. 1).

By the middle of February the separation of the plates of sporogenous cells from each other was marked (fig. 2). By this time the tapetal cells, especially those on the inner side of the sporangium, were beginning to break down and appeared as much distorted cells, while the tabular cells which formed the inner layers of the sporangium wall became very much flattened and took stain more readily (fig. 2).

In the mature anther the cell walls had all disappeared except the well-developed endothecium inside of the epidermis. There are two pollen sacs which dehisce longitudinally with no definite stomium.

The megasporangium

The earliest stage observed showed the megasporangium as a rather massive protuberance inward from the side wall of the ovary cavity. On January 21 some of the ovules showed the beginning of the inner integument. By February 16 the outer integument had begun its development, and the growth of the ovule had been such that a median longitudinal line through the ovule had been shifted from practically perpendicular to the longitudinal axis of the carpel to a position nearly parallel with it. The growth of the integuments from this time on was somewhat irregular, sometimes the outer and sometimes the inner growing more rapidly. There was in either case apparently an excessive development of integuments, so that when the embryo sac was ready for fertilization they not only closed over the nucellus, but lay in folds above it (fig. 3). At this stage the innermost layer of cells of the inner integument had much greater cytoplasmic contents than the other cells.

In the nucellus, which was relatively massive, there was evidently one archesporial cell picked out. The earliest stage examined showed a single sporogenous cell and two parietal cells (fig. 4), which evidently arose by the periclinal division of the primary parietal cell. The further division of the parietal cells continued steadily, so that within four weeks there were often more than 10 parietal cells lying between the sporogenous cell and the epidermis (fig. 5). Very often a periclinal division of the epidermal cells of the nucellus occurred (fig. 5). The time when the mother cell went into synapsis varied greatly, some of the ovules showing this condition as early as February 16 (fig. 5), while others showed the mother cell in a presynaptic condition as late as March 22. However, at this later date the majority of mother cells were in synapsis.

Although the division of the megaspore mother cell was not observed, it evidently gave rise to a linear tetrad of megaspores. Above the micropylar end of the young embryo sac there were often three deeply stained masses (fig. 6), which had the same appearance as recognized abortive megaspores in other forms.

As the embryo sac developed, the further periclinal and anticlinal divisions of the parietal tissue continued, so that when the sac was ready for fertilization there were often as many as 30 layers of cells lying above it. Very often the tip of the nucellus developed into a somewhat slender beak, which took the form of the more or less twisted integuments (fig. 3).

The female gametophyte

After the formation of the row of megaspores, the innermost or functional spore immediately began division. In material collected on March 21 and killed on March 25 the embryo sacs were practically all in the four-celled stage. The two-celled stage figured (fig. 6) was of material killed on March 25 of the preceding year. It would seem that the embryo sac remained in the four-celled stage for some time, since material killed on March 30, April 3, and April 5 showed practically all the sacs in this condition. An ovule killed in the afternoon of April 5 showed the simultaneous division of these four nuclei to form the light nuclei of the completed sac.

In the mature embryo sac the egg has the usual organization, with the vacuole toward the micropylar end, but the synergids are almost entirely without vacuoles and the position of their nuclei is irregular (fig. 7). The antipodals are usually evanescent.

The male gametophyte

The stages of pollen tube formation and of fertilization were not observed, and this fact, under ordinary circumstances, might have led to the belief that the form was parthenogenetic. This makes peculiarly fortunate the precaution which was taken early in the season, of preventing pollination in some of the pistillate catkins. As has been described previously, this was accomplished by covering with paper sacks seven of the twigs bearing pistillate flowers before pollen began to fly. Although each of these twigs bore about five catkins and each catkin contained several pistils, there was not a single case of seed formation observed. One may safely infer that parthenogenesis is not of usual occurrence in this form.

The endosperm

The fusion of the polar nuclei and male cell was not observed, but must have occurred about April 15. Material killed on this date showed the eight-nucleate sac, but material killed on April 16 showed the large endosperm nucleus. It may be that division of this nucleus did not take place immediately, since all the material examined within the five days following this shows it undivided. Material killed on April 22 showed two free endosperm nuclei. After this, the simultaneous free nuclear division goes on rapidly, so that by the time the division of the fertilized egg occurred there were sometimes as many as 35 of these parietally placed nuclei to be seen in a single section (fig. 8*a*). The increase in size of the sac, due to growth of the ovule itself, and the breaking down of tissues about the sac and especially below it was very great. By May 10 the endosperm was seen as a very thin layer of cytoplasm about the embryo sac, which extended over three-quarters of the length of the ovule, which itself measured as much as 6 mm. About this time the formation of walls in the endosperm began, and this was followed by a centripetal growth of tissue so regular as to give the endosperm the appearance of being made up of plates of cells. These cells were large and contained unusually large nuclei. This was especially true of the tissue at the chalazal end, which was a very loose tissue and contained large, irregular nuclei, which were possibly produced by the fusion of several nuclei.

The embryo

After free nuclear division had continued for some time in the endosperm, the division of the fertilized egg occurred. The first two-celled embryos seen were in material which was killed April 30. It was a matter of indifference in which plane the first division wall should lie, so that in some cases (fig. 8) the first wall was parallel to the longitudinal axis of the embryo sac, while in others the position was the horizontal one almost universal in the embryos of angiosperms. In whichever plane the first division occurred, other divisions followed rapidly in all planes, so that there was in no case a slender suspensor formed. In fact, in the young stages the embryo was somewhat pear-shaped, with the massive suspensor only slightly narrower than the body of the embryo (fig. 9*a*).

The growth of the embryo, and indeed of the whole fruit, was very rapid. Figs. 8*a*, 9*a*, and 10*a*, which were drawn to the same scale, show the increase in size of the embryo itself within the first five weeks. Fig. 9 shows the detail of a few cells of the endosperm and the outermost layer of cells of the embryo at the micropylar end of the embryo sac. It will be noticed that at this stage, when the embryo consisted of a relatively large number of cells, there was as yet no evidence of the appearance of cotyledons (fig. 9*a*), the embryo proper still appearing as a globular mass of cells. Shortly after this, however, the cotyledons began to appear as protuberances from the distal end of the embryo, and within a few weeks there was the well-organized embryo as shown in the diagram (fig. 10*a*.) Cell detail of the suspensor region of the embryo is shown in fig. 10, where it will be noticed in comparison with fig. 9, which shows some of the outer cells of this region, that there had been but slight increase in the size of the cells of this region. Fig. 11 shows, under slightly less magnification than fig. 10, the detail of cell structure of the root end of the embryo and the lower portion of the suspensor. At this stage, examination even under low magnification showed a clearly defined periblem (fig. 10*a*). Under higher magnification (fig. 11) it was seen that plerome, dermatogen, and calyptrogen all arose from a common group of meristematic cells, and that these regions were not yet clearly defined. The periblem was more easily picked out by the larger size of its cells and their relatively less cytoplasmic contents. At this stage of the embryo it was evident that the cotyledons were to be net-veined, as might be expected. The rapid growth of the embryo continued until at maturity it approached 1 dm. in length. Fig. 12 is a diagram showing the size of the seed and the position of the embryo within it.

The seed

The tremendous rate of growth of the seed made it seem worth while to look somewhat into the method of food supply. In the development of the ovule there was a very early differentiation of tissue in the chalaza. On March 25, when the embryo sac was in the two-nucleate stage, there was seen extending across the chalaza, from the base of the inner integument, a rather narrow layer of cells, which, having more densely granular cytoplasmic content, took a deeper stain than the other cells of the region (fig. 14). Immediately outside of this layer of cells, which for convenience we will speak of as the nutritive layer, there was a layer of cells elongated transversely to the axis of the ovule, which was continuous with the vascular bundle of the funiculus (figs. 13 and 14).

The cells of the nutritive layer divided repeatedly, so that by the time the development of the embryo sac was completed there was quite a mass of them showing very clearly, even under low magnification, on account of their deeper stain. At about the time that the embryo sac was ready for fertilization, the appearance of these cells changed, and under low magnification they could now be picked out by their lighter stain. Higher magnification showed them to have almost no granular cytoplasmic content (fig. 15). Very shortly after this it was seen that there was being deposited in the cells some reserve material, probably tannin, which did not stain with the iron-haemotoxylin combination. This deposition began at the periphery of the cell and proceeded toward the interior (fig. 16). Finally the cells were so packed with material that it was impossible to distinguish even the nuclei.

As the endosperm nuclei began division, growth in all parts of the ovule became very rapid, and this rapid rate of growth continued up to the maturity of the seed. While this was going on the reserve material in the nutritive layer began to disappear gradually, and as it went the cells of the perisperm immediately above it, which had increased considerably in size, were seen to contain numbers of starch grains (fig. 17).

Coincident with the differentiation of the nutritive cells is the development of the conducting cells immediately below it. Fig. 14 shows the elongation of the cells of this region, and their general relation to the nutritive layer when it could first be distinguished in the condition of the ovule seen in fig. 13. Somewhat later the thickening of the walls of these elongated cells to form tracheary tissue was seen (fig. 18). At the time when the nutritive layer is most conspicuous on account of its large amount of reserve material, a section tangential to the disk of nutritive cells immediately below it shows the conducting tissue in the form of a radiating plate of tracheary tissue (fig. 19), so that very often in the longitudinal section through the ovule there were found transverse and oblique sections of the vessels rather than longitudinal as seen in fig. 17.

At maturity the seed consisted of an embryo with two thin, very broad cotyledons. About the embryo was a considerable mass of large-celled endosperm tissue whose cells were packed with starch. The perisperm was a relatively thin layer of loose tissue. These regions, as well as the relative thickness of the seed coats, are seen in the diagram (fig. 12). Immediately outside of the epidermal layer of the nucellus there is a thick layer of cutin, which entirely covers the micropylar end of the seed. So closely abutting this layer of cutin that it is impossible to tell whether it was laid down by these epidermal cells of the nucellus or by the innermost layer of cells of the integument, lies the inner integument. It seems probable that the cells of both these closely abutting layers may have contributed to the layer of cutin lying between them. These cells of the innermost layer are the only cells of the inner integuments which are at all conspicuous. In these cells the walls had become irregularly thickened, so as to have a pitted appearance in surface view. The outer layers of cells of this integument have all collapsed, as is best seen in fig. 20. In the outer integument the development had been different, for while here too the outermost layer of cells had unthickened walls, all the remaining cells had the pitted wall (fig. 20), giving in section a rather conspicuous seed coat. It is interesting to note that the outer integument, which in the early stages of the development of the ovule seemed excessively developed (fig. 7), here extended but a very little distance beyond the tip of the nucellus (fig. 12).

Discussion

In handling a form about whose position taxonomically there have been so many differences of opinion, it seems worth while to attempt to summarize the forms which are similar to *Leitneria* in various particulars, in order to see whether it could be placed on the basis of its morphology.

In the case of the stamen, there is no particular in which it differs strikingly from the stamen of other catkin-bearing forms. The microsporangia pass the winter in the spore mother cell stage, as do those of *Salix glaucophylla* (2), *Alnus glutinosa* (3), *Corylus americana* (3), and *Ulmus americana* (4). That such a character should be given little weight taxonomically, however, becomes evident when one looks at such a group as Hamamelidaceae. SHOEMAKER (5) in his study of this family reports all variations in the stage in which the stamens of the different genera of spring-flowering forms pass the winter. Of *Liquidambar Styraciflua* he says "stamens are only small protuberances which do not show any archesporium"; of *Fothergilla Gardeni*, "they pass the winter in the pollen mother cell stage"; while of *Hamamelis arborea* and *Corylopsis pauciflora*, the stamens "pass the winter containing nearly mature pollen grains with two free nuclei."

The developing megasporangium containing a single archesporial cell differs from most of the Amentiferae yet reported upon. However, this condition is found in *Betula alba* (6) and in *Alnus glutinosa* (6), and is usual in various species of *Salix* (2), and therefore the character of a multicellular archesporium could hardly be considered a group character. Again, the extent of tissue development in the nucellar region is so variable a character that one finds reports of deeply placed embryo sacs, such as are found in *Leitneria*, reported in *Casuarina* (**7, 8**), in *Triticum* (**9**), in *Cuphaea* (**10**), and in other entirely unrelated forms.

Another character which *Leitneria* has in common with the majority of Archichlamydeae is the initiation of the development of the embryo sac by a megaspore rather than by a megaspore mother cell, so that while a tetrad of spores is formed, a single megaspore functions. In the embryo sac that develops from this megaspore the synergids are characterized by being full of cytoplasm, rather than by having the large, distinct vacuole, as often found in the antipodal end of the cell. This, while a character not often reported for the synergids of forms even where the synergids are relatively small, is of course not a character which would hold any weight taxonomically. The ephemeral antipodals are found in many forms, as in the Salicaceae and Cupuliferae.

After fertilization, the behavior of the endosperm nucleus and of the fertilized egg is in no way extraordinary; while extreme in some cases, as in the great development of free nuclei of the endosperm before the division of the fertilized egg occurs, still there is no character of first importance which would indicate relationship with one family or another. Thus the more or less extensive development of free endosperm nuclei before the segmentation of the egg is a character shared by *Piper* (**11**) and *Asclepias* (**12**). The very regular centripetal growth of endosperm tissue after walls appear is extreme, and is rarely found so well developed in angiospermous seeds. The most striking character of the embryo itself is the massive suspensor. But this character, too, is shared by most of those forms, such a *Peperomia pellucida* (**13**), in which the first division of the fertilized egg may be longitudinal rather than transverse. It is of interest to find here again a form in which there is no fixed sequence of cell divisions in the development of the embryo, such as have long been emphasized in such forms as *Capsella*.

One might go on indefinitely pointing out some particular in which *Leitneria* resembles one or the other of the Archichlamydeae, without in the end establishing any definite relationship with a specific group. The thing which does impress one, however, in looking over the work that has been done on Amentiferae, is the general resemblance to gymnosperms. Thus in working through the life history of such a form as *Leitneria*, one is constantly reminded of gymnosperms by one detail of structure or another. Thus, in the wood of *Leitneria*, one finds tracheae which show in every case an incomplete disappearance of the cross walls of the rather short cells of which they are composed, so that in section one sees clearly at the periphery of the vessel the remains of these walls. More striking than this incomplete disappearance of septa across the tracheae is the predominance of tracheids with bordered pits.

As might be expected, it is in the study of the reproductive parts that one finds the most striking reminders of gymnosperm structure. Thus it is a relatively easy matter to imagine the derivation of a catkin from the compound strobilus found among gymnosperms. In either case the structure is made up of a series of bracts in whose axil stand sporophylls. In both gymnosperms and the Amentiferae the characteristic number of megasporophylls per bract is two, but it is in no way surprising to find this number occasionally reduced to one, as in *Leitneria*, while in the larger number of miscrosporophylls per bract we have a parallel among Gnetales, the only group of gymnosperms which has the compound staminate strobilus.

Within the carpel the ovule also has several characters in which it resembles that of gymnosperms. Thus we find that it is a relatively massive structure, with a large development of nucellar tissue above the megaspore, so that the female gametophyte when it develops is deeply placed in tissue.

Summary

The microsporangium passes the winter in the spore mother cell stage.

In the solitary ovule, the archesporial cell divides early; on January 21 there were two parietal cells above the single archesporial cell.

There is a large development of parietal tissue in the ovule, as many as thirty layers of cells lying above the embryo sac at its maturity.

Practically all megaspore mother cells were in synapsis on March 22.

A linear tetrad of megaspores was evidently formed.

By April 7 practically all embryo sacs showed the eight-nucleate female gametophyte.

After fertilization the endosperm nucleus divides repeatedly, giving rise to a large number of free nuclei before the division of the fertilized egg occurs.

After wall formation in the endosperm begins, there is an extremely regular centripetal growth of tissue.

The first division of the fertilized egg may be longitudinal or transverse; in either case a massive suspensor is formed.

The young embryo is a pear-shaped mass which is composed of hundreds of cells before the cotyledons appear.

In the root tip of the embryo, calyptrogen, dermatogen, and plerome arise from a common meristematic group of cells.

The growth of the seed is very rapid, and at maturity it contains a large, flat, dicotyledonous embryo, a thin layer of endosperm tissue, and a few layers of perisperm cells.

The seed coat is formed mostly from the outer integument, the inner integument contributing only its innermost layer of cells.

The morphology of *Leitneria* is not such as would make it possible to place it definitely in any of the families of the Archichlamydeae, but, in common with other Amentiferae, it suggests the possibility of the derivation of Amentiferae from such forms as one finds among the gymnosperms which have compound strobili.

The author is indebted to Professors JOHN M. COULTER and CHARLES J. CHAMBERLAIN, under whose direction this work was done, and to the staff of the Missouri Botanical Garden of St. Louis for aid in collecting material.

THE UNIVERSITY OF CHICAGO

LITERATURE CITED

1. TRELEASE, WILLIAM, *Leitneria floridana.* Rept. Mo. Bot. Garden **6:** 1–26. *pls. 30–44.* 1895.
2. CHAMBERLAIN, CHARLES J., Contributions to the life history of *Salix.* BOT. GAZ. **23:** 147–179. *pls. 12–18.* 1897.
3. ———, Winter conditions of certain sporangia. BOT. GAZ. **25:** 124–128. *pl. 11.* 1898.
4. SHATTUCK, CHARLES H., A morphological study of *Ulmus americana.* BOT. GAZ. **40:** 209–223. *pls. 7–9.* 1905.
5. SHOEMAKER, D. N., On the development of *Hamamelis virginiana.* BOT. GAZ. **39:** 248–266. *pls. 6, 7.* 1905.
6. BENSON, MARGARET, Contributions to the embryology of the Amentiferae. I. Trans. Linn. Soc. London **3:** 409–424. *pls. 67–72.* 1894.
7. TREUB, M., Sur les Casuarinées et leur place dans le système naturel. Ann. Jard. Bot. Buitenzorg **10:** 145–231. *pls. 12–32.* 1891.
8. FRYE, T. C., The embryo sac of *Casuarina stricta.* BOT. GAZ. **36:** 101–113. *pl. 17.* 1903.
9. KOERNICKE, M., Untersuchungen über die Entstehung und Entwickelung der Sexualorgane von *Triticum* mit besonderer Berücksichtigung der Kerntheilung. Verhandl. Natur. Hist. Ver Preussen Rheinl. **53:** 149–185. 1896.
10. GUIGNARD, L., Recherches sur le sac embryonnaire des Phanérogames Angiospermes. Ann. Sci. Nat. Bot. VI. **13:** 136–199. *pls. 3–7.* 1882.
11. JOHNSON, D. S., On the development of certain Piperaceae. BOT. GAZ. **34:** 321–340. *pls. 9, 10.* 1902.
12. FRYE, T. C., A morphological study of certain Asclepiadaceae. BOT. GAZ. **34:** 389–413. *pls. 13–15.* 1902.
13. JOHNSON, D. S., On the endosperm and embryo of *Peperomia pellucida.* BOT. GAZ. **30:** 1–11. *pl. 1.* 1900.

EXPLANATION OF PLATES XVIII–XX

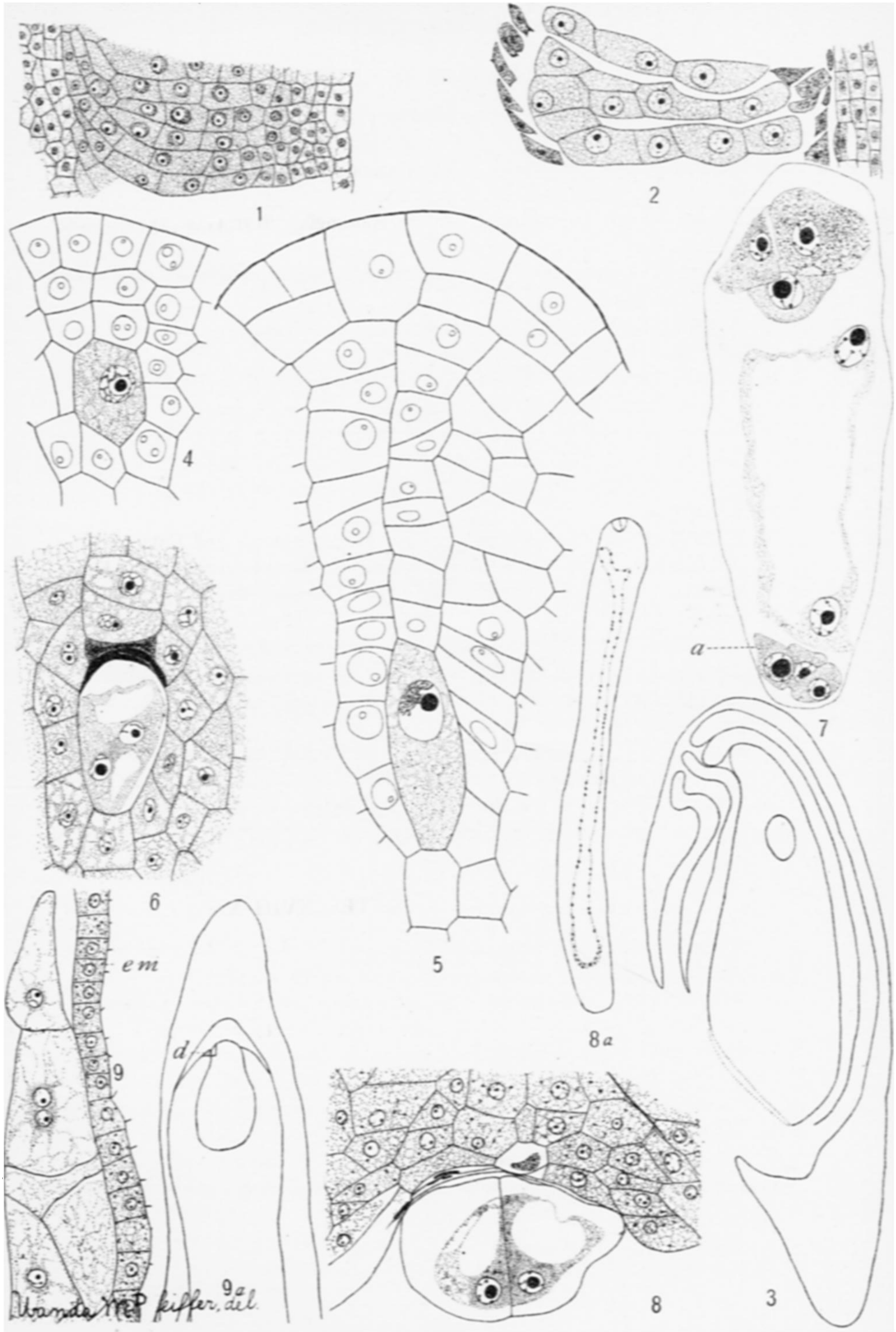
All figures were made with an Abbé camera lucida. A Zeiss microscope was used with ocular 4 and objectives 2/3 and 2 mm.

Abbreviations: *a*, antipodals; *en*, endosperm; *em*, embryo; *n*, nutritive layer; *c*, conducting tissue; *o*, outer integument; *i*, inner integument.

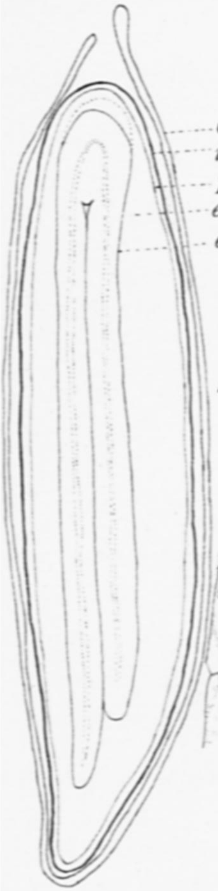
FIG. 1.—Portion of a longitudinal section of a stamen in winter condition; ×600.

FIG. 2.—Similar portion of a stamen Feb. 16, showing the separation of the plates of spore mother cells and the breaking down of tapetal cells; ×600.

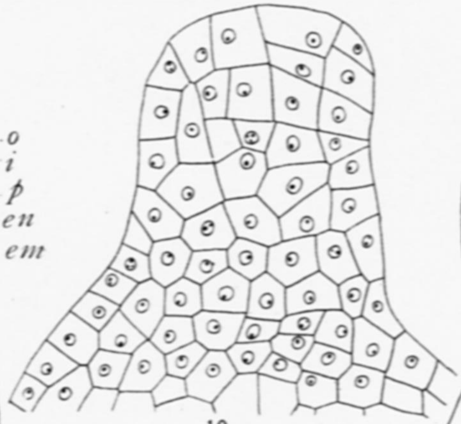
FIG. 3.—A diagram through the ovule when the embryo sac is mature, showing the position of the embryo sac and the great development of integuments; ×600.



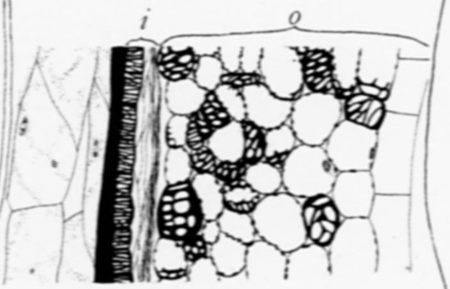
PFEIFFER on LEITNERIA



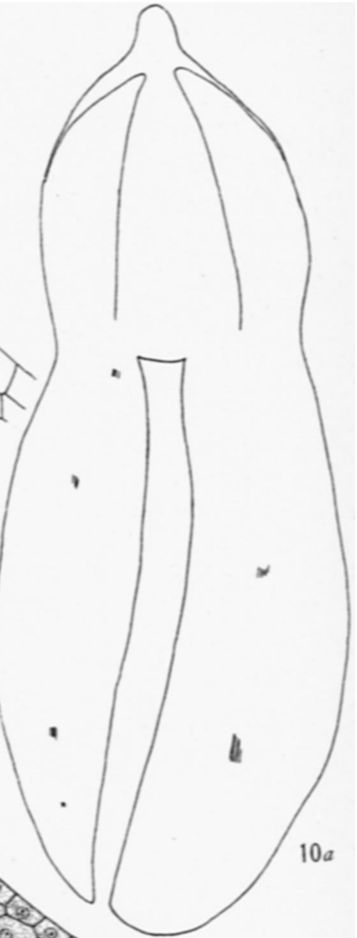
12



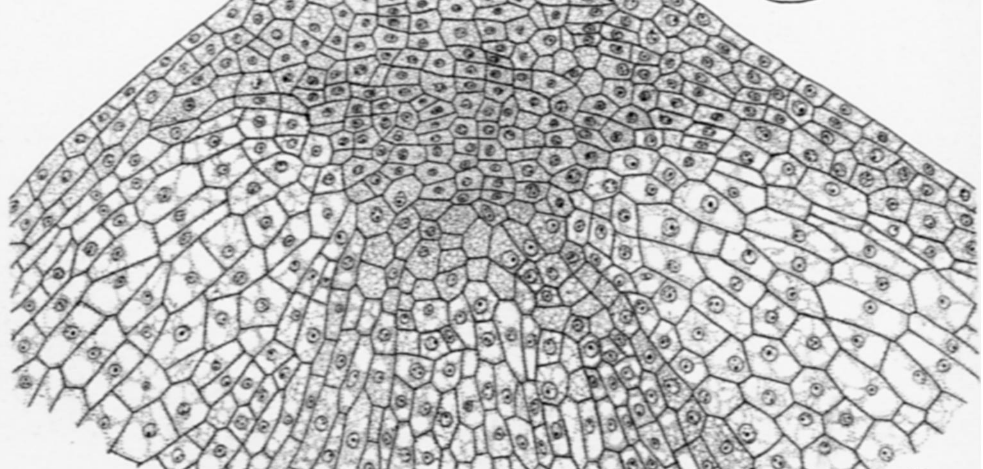
10



20



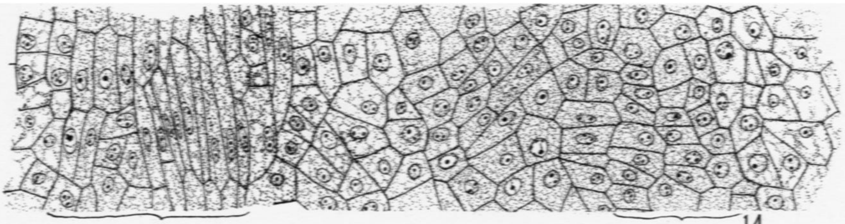
10a



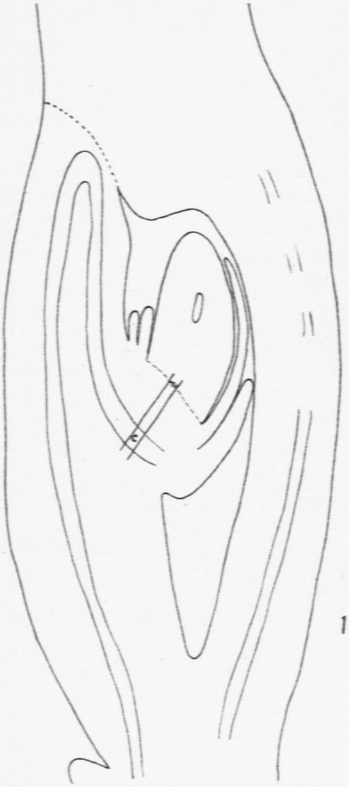
11

Wanda M. Pfeiffer, del

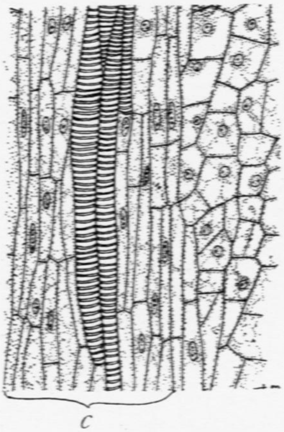
PFEIFFER on LEITNERIA



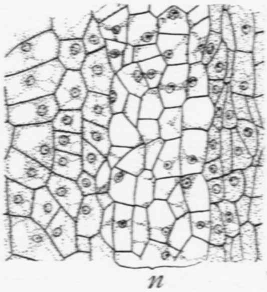
14



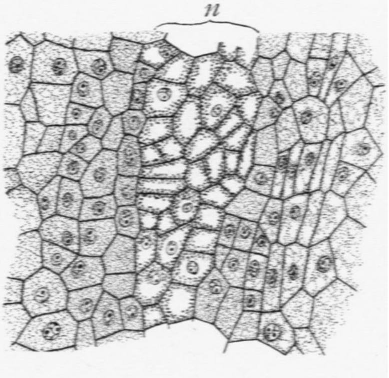
13



18

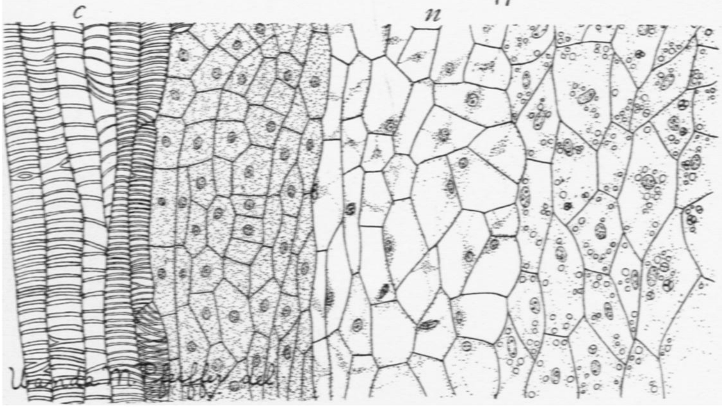


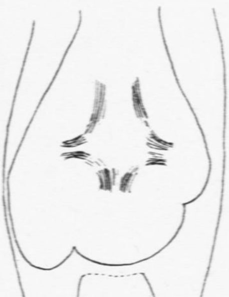
15



16

17





19

PFEIFFER on LEITNERIA

FIG. 4.—Portion of nucellus of ovule on Jan. 21, showing the single sporogenous cell and two parietal cells; ×550.

FIG. 5.—Portion of nucellus four weeks later, showing the periclinal division of some of the epidermal cells, the further development of parietal tissue, and the megaspore mother cell in synapsis; ×600.

FIG. 6.—Two-nucleate female gametophyte, with three abortive megaspores immediately above it; ×600.

FIG. 7.—The eight-nucleate embryo sac; ×600.

FIG. 8.—Two-celled embryo, showing the longitudinal division of the fertilized egg; ×600.

FIG. 8*a*.—Diagram showing the position of the two-celled embryo seen in fig. 8, and the extensive endosperm in the free nuclear condition; ×55.

FIG. 9.—Detail of a portion of the outer layer of cells of the embryo seen at *d* in fig. 9*a*, and the contiguous endosperm cell; ×600.

FIG. 9*a*.—Diagram showing position of the young embryo and the absence of a slender suspensor; ×55.

FIG. 10.—Detail of the suspensor region of the embryo seen in diagram in fig. 10*a;* ×600.

FIG. 10*a*.—Diagram of an older embryo, showing the developing cotyledons; ×55.

FIG. 11.—Detail of the cell structure of root end of the embryo and the lower portion of the embryo; ×450.

FIG. 12.—Diagram of a mature seed, showing the position of the embryo and the extent of the endosperm, perisperm, and seed coats; ×12.5.

FIG. 13.—Diagram showing a young ovule with the position of the nutritive layer shown in a broken line, and the region shown in detail in fig. 14 marked out; ×55.

FIG. 14.—Detail of cell structure of region of chalaza marked out in fig. 13, showing the elongating cells whose further development is seen in figs. 17 and 18, and the appearance of the nutritive layer (*n*) when it can first be distinguished; ×600.

FIG. 15.—Detail of nutritive tissue somewhat later, when the cells seem almost free of cytoplasm; ×600.

FIG. 16.—Detail of nutritive tissue after deposition of reserve material has begun; ×600.

FIG. 17.—Detail of region seen in fig. 14, after the cells of the nutritive layer again lost their reserve material; endosperm cells with starch; ×600.

FIG. 18.—The region *c* of fig. 14 when the nutritive tissue is in the condition seen in fig. 15.

FIG. 19.—Diagram showing radiating plates of conductive tissue in the chalaza.

FIG. 20.—Detail of seed coat and outer portion of perisperm.